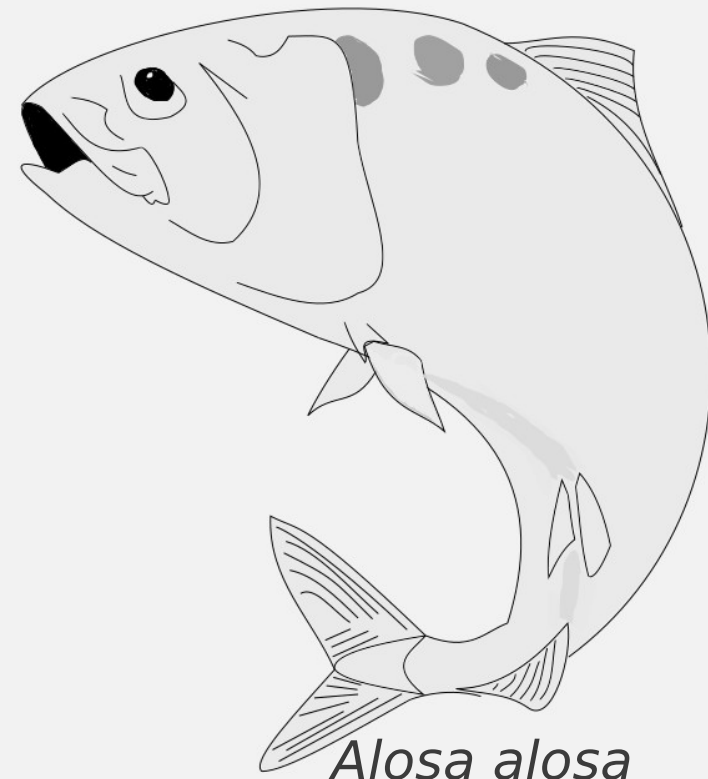


flirtyShadBrain: un modèle de reproduction simulée pour les populations d'aloses (*Alosa alosa*)

Présenté par **Alexis Paumier**
Doctorant à IRSTEA Bordeaux, France

Alexis Paumier, Hilaire Drouineau,
et Patrick Lambert



Alosa alosa

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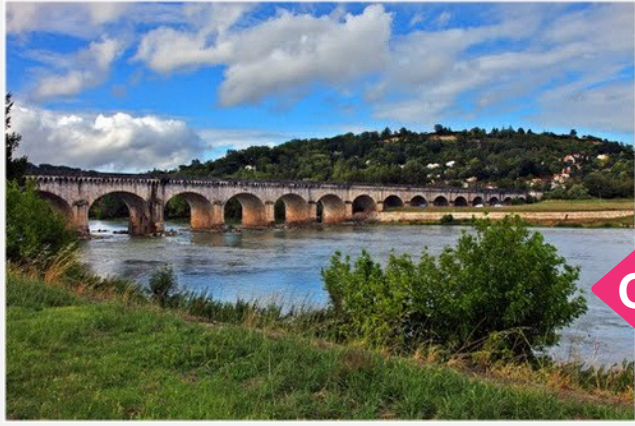
Alexis Paumier, Hilaire Drouineau,
et Patrick Lambert



Site d'étude: les rivières abritant les populations d'alose les plus abondantes (...historiquement)



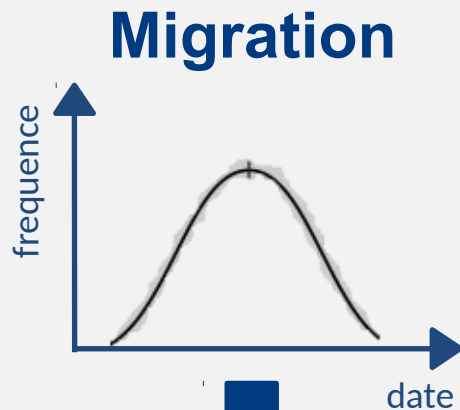
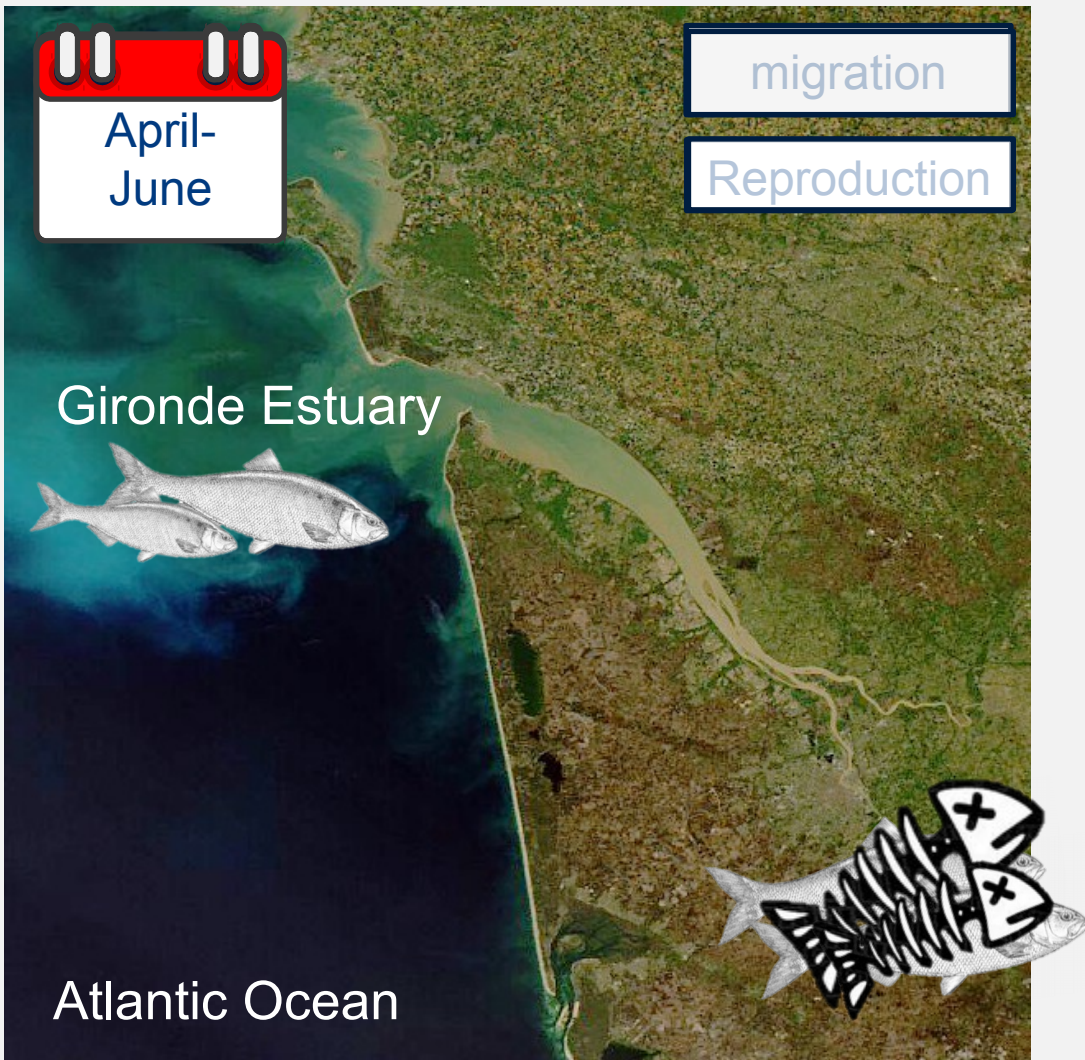
Dordogne River



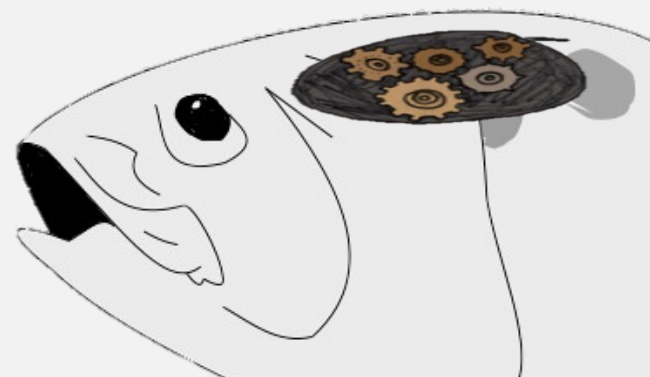
Garonne River



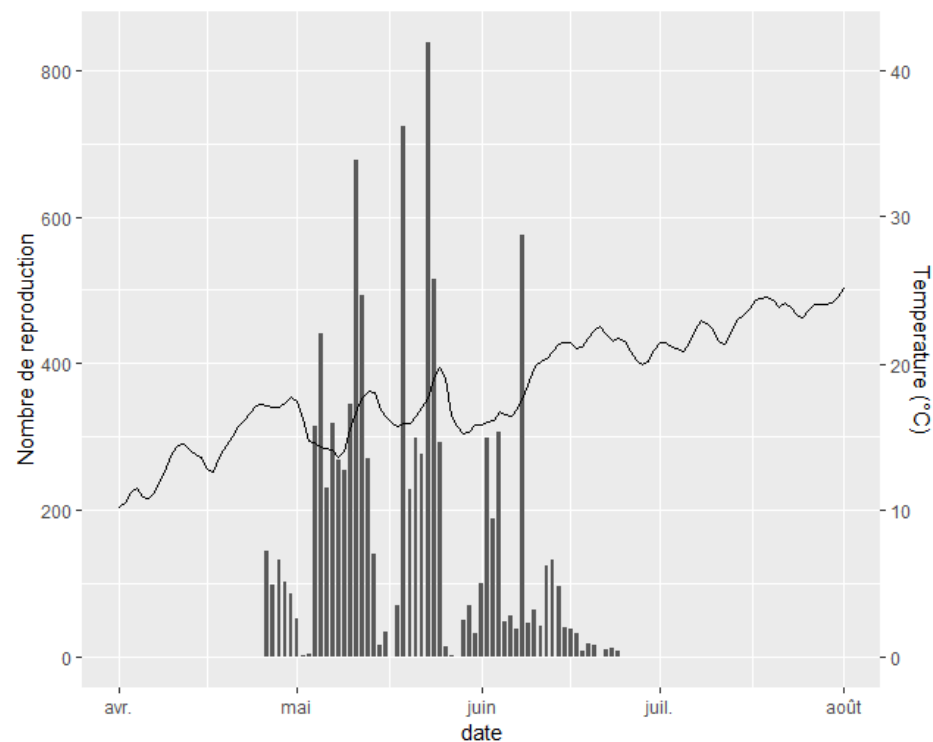
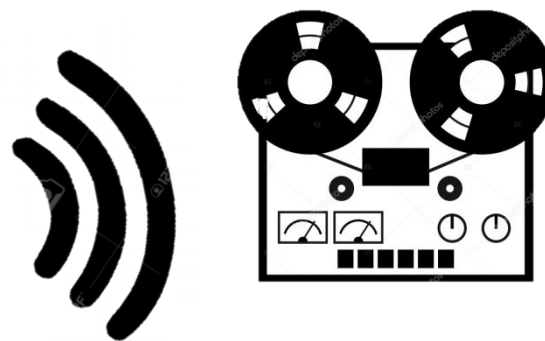
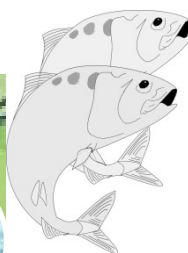
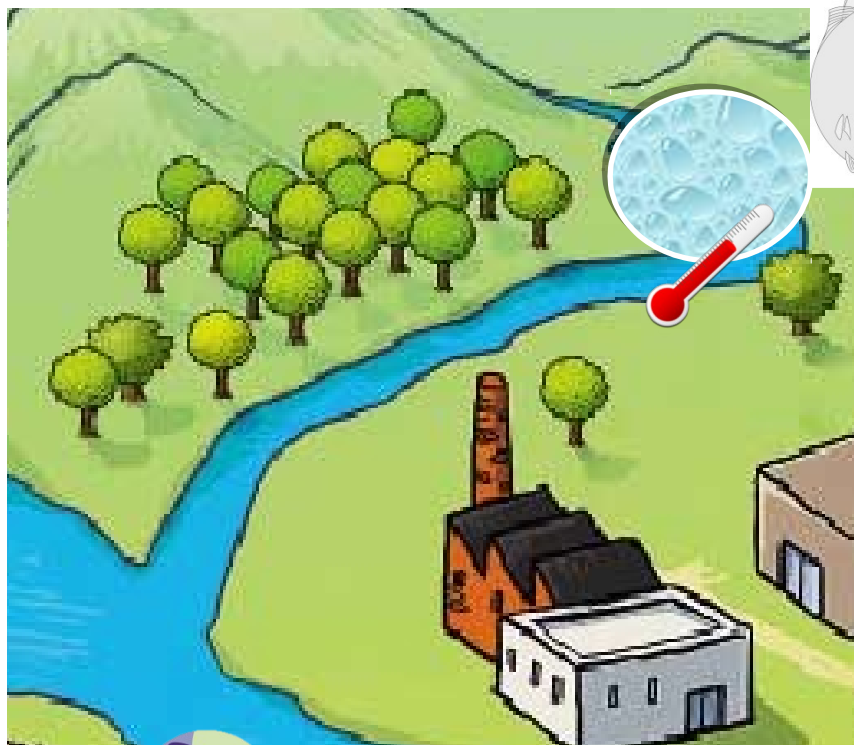
flirtyShadBrain: un modèle un modèle mécaniste



Reproduction



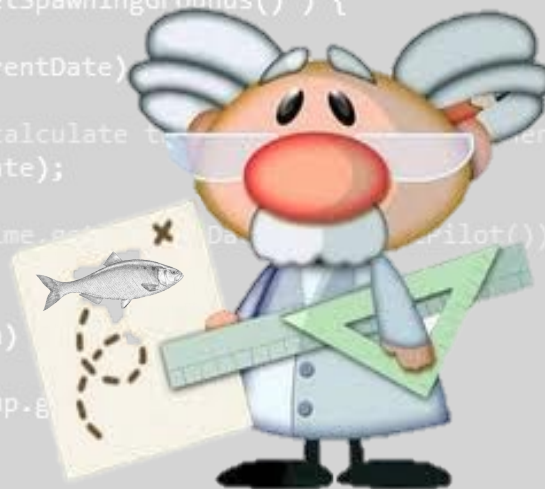
M&M: 14 années de suivi journalier sur deux rivières



flirtyShadBrain: un modèle de reproduction simulée

```
currentDate = Time.getCurrentDate(group.getPilot());  
totalReproductiveActs = 0;
```

```
for (Spawn... getEnvironment().getSpawningGrounds() ) {
```



Modèle déterministe
Réseau de neurones calibré
par un algorithme génétique:
CMA-ES

flirtyShadBrain: un modèle de reproduction simulée

Patron d'arrivée

```

currentDate = Time.getCurrentDate(group.getPilot());
totalReproductiveActs = 0;
for (SpawningGround<Shad> ground : group.getEnvironment().getSpawningGrounds() ) {
    double temperature = ground.getStimulus("temperature",currentDate);
    int reproductiveActs = 0;
    //survival of offspring that is born this day ( use to calculate the fitness of the spawner)
    offspringSurvival = ground.getJuvenileSurvival(currentDate);
    // Arrival
    System.out.println("At "+ground.getName()+" the "+ Time.getCurrentDate(group.getPilot()));
    for (Shad shad : ground.getSpawners(group)) {
        if (shad.isReadyToSpawn(currentDate, group)) {
            if (genUniform.nextDouble() < probabilityToSpawn) {
                shad.addDayOfSpawn( Time.getCurrentDate(group.getPilot()));
                shad.addFitness(offspringSurvival);
                nbReproductiveActs ++;
                //System.out.println(" fish "+shad.hashCode()+" active since "+
                // ChronoUnit.DAYS.between(shad.getDayOfArrival(),Time.getCurrentDate(group.getPilot())));
                // produce "gamete"
                if (genUniform.nextDouble()<offspringSurvival) {
                    ground.addGamete(group, shad.duplicate(group.getPilot()));
                }
            }
        }
    }
}

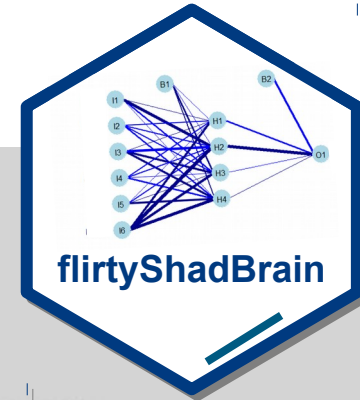
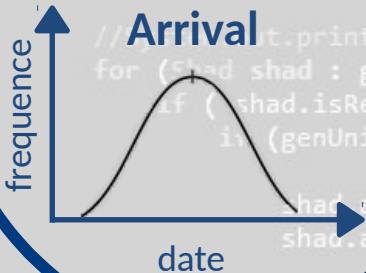
```

Spawning

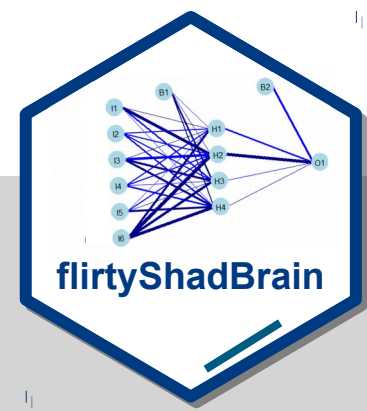
stock



Arrival



flirtyShadBrain: un modèle de reproduction simulée



```

currentDate = Time.getCurrentDate(group.getPilot());
totalProductiveActs = 0;

for (SpawningGround<Shad> ground : group.getEnvironment().getSpawningGrounds() ) {
    da...ture = ground.getStimulus("temperature",currentDate);
    int productiveActs = ...
    //survival of offspring that is born this day ( use to calculate the fitness of the spawner)
    offspringSurvival = ground.getOffspringSurvival(currentDate);

    //t.println("At " +ground.getName()+ " the " + Time.getCurrentDate(group.getPilot()));
    for (Shad shad : ground.getShads()) {
        if (shad.isReadyToSpawn(currentDate, group)) {
            i (genUniform.nextInt() < probabilityToSpawn) {
                shad.addDayOfSpawn(currentDate);
                shad.addFitness(offspringSurvival);

                nbOfBroodProduced++;
                //System.out.println(" fish "+shad.hashCode()+" active since "+
                //Time.getCurrentDate(group.getPilot())+" arrived at "+Time.getCurrentDate(group.getPilot()));
                produce "offspring" {
                    (genUniform.nextInt() < probabilityToSpawn) {
                        ground.addGamete(group, shad.getGamete(group.getPilot()));
                    }
                }
            }
        }
    }
}

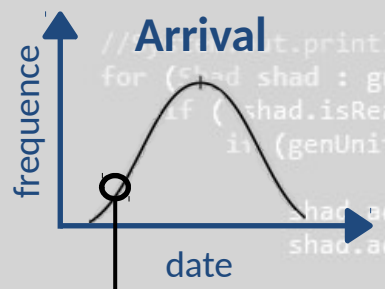
```

Spawning stock

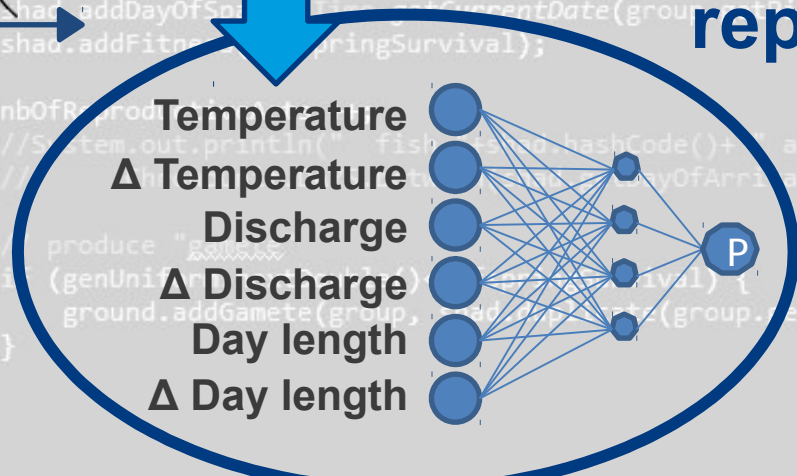


Perceptible par le poisson

Tactique de reproduction



Arrival



flirtyShadBrain: un modèle de reproduction simulée

```

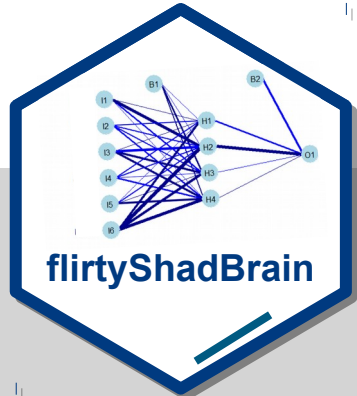
currentDate = Time.getCurrentDate(group.getPilot());
totalProductiveActs = 0;

for (SpawningGround<Shad> ground : group.getEnvironment().getSpawningGrounds())
    date = ground.getStimulus("temperature",currentDate);
    int productiveActs = 0;
    //survival of offspring that is born this day ( use to calculate the
    offspringSurvival = ground.getJuvenileSurvival(currentDate);

//t.println("Arrival of the " + Time.getCurrentDate());
for (Shad shad : ground.getSpawners(group)) {
    if (shad.isReadyToSpawn(currentDate, group)) {
        i = (genUniform(0, 1) * Spawn) {
            shad.addDayOfSpawn( Time.getCurrentDate(group.getPilot()));
            shad.addSuccess(offspringSurvival);
            productiveActs ++;
            out.println("fi" + shad.hashCode() + " ");
            Unit.DAY.between(shad.getDaysArrived(), Time.getCurrentDate(group.getPilot()));
            if (shad.nextDayOfSpawn() == true) {
                Gamete(group, shad.dup());
            }
        }
    }
}
}
}

```

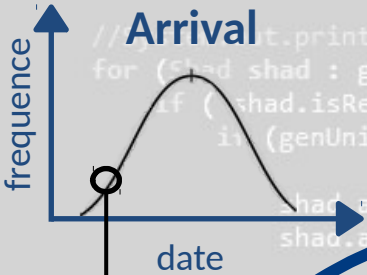
Spawning stock



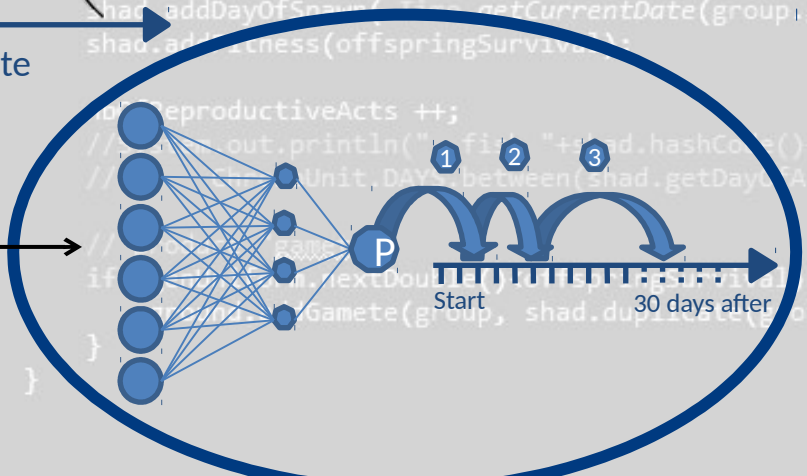
flirtyShadBrain



Biological mill



Tactique de reproduction



- 30 jours maximum
- 3 reproductions maximum
- Espacées de 2 jours

(Bernardin and Tentelier, unpublished data; Kissil, 1974; Olney et al. 2006; Aunins et al. 2009 ; Maltais et al. 2010; Lowerre-Barbieri et al. 2011; Rosset, 2017)

flirtyShadBrain: un modèle de reproduction simulée

```

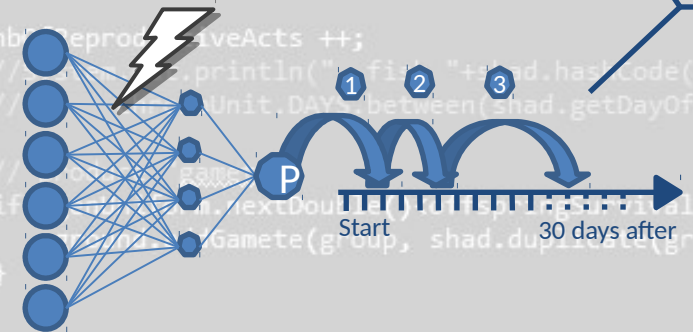
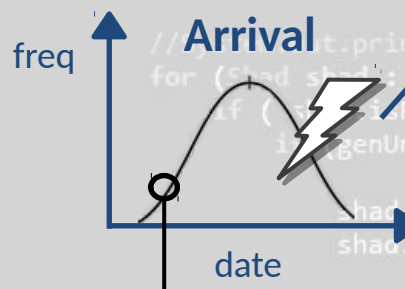
currentDate = Time.getCurrentDate(group.getPilot());
totalReproductiveActs = 0;

for (SpawnableShad ground : group.getEnvironment().getSpawningGrounds() ) {
    double temperature = ground.getStimulus("temperature",currentDate);
    int reproductiveActs = 0;
    //survival of offspring that is born this day ( use to calculate the fitness of the
    offspringSurvival = ground.getJuvenileSurvival(currentDate);

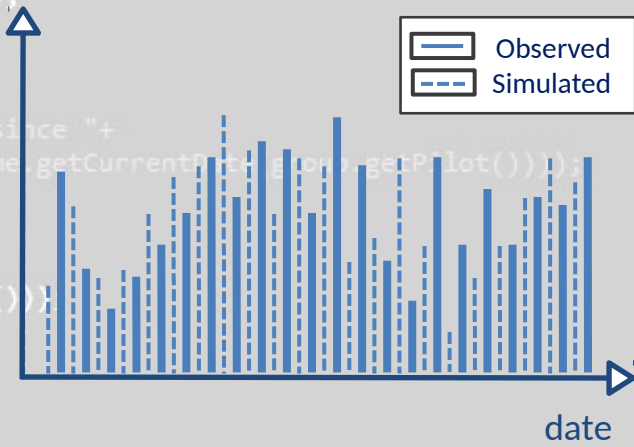
    //Println("At " +ground.getName()+ " the " + Time.getCurrentDate(group.getPilot()));
    for (Shad shad : ground.getSpawners(group)) {
        if (shad.isReadyToSpawn(currentDate, group)) {
            if (genUniform.nextDouble() < probabilityToSpawn) {
                shad.addDayOfSpawn( Time.getCurrentDate(group.getPilot()));
                shad.addFitness(offspringSurvival);

                nbReproductiveActs ++;
                //Println("fitness of "+shad.hasCode()+ " active since "+
                //Unit.DAY.between(shad.getDayOfArrival(),Time.getCurrentDate(group.getPilot()));
                if (genUniform.nextDouble() < probabilityToSurvive) {
                    Gamete(grou, shad.duplicate(group.getPilot()));
                }
            }
        }
    }
}

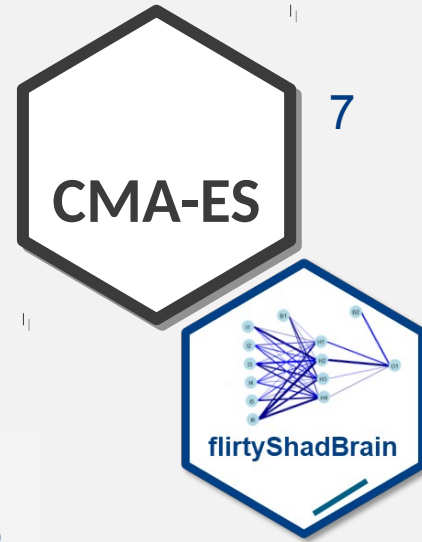
```



Sum of squared errors of prediction (SSE)



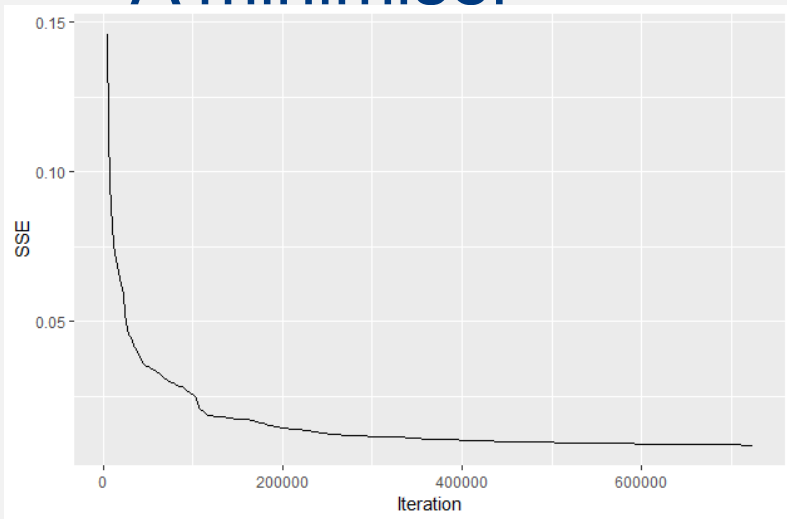
flirtyShadBrain: la construction de la fonction objectif



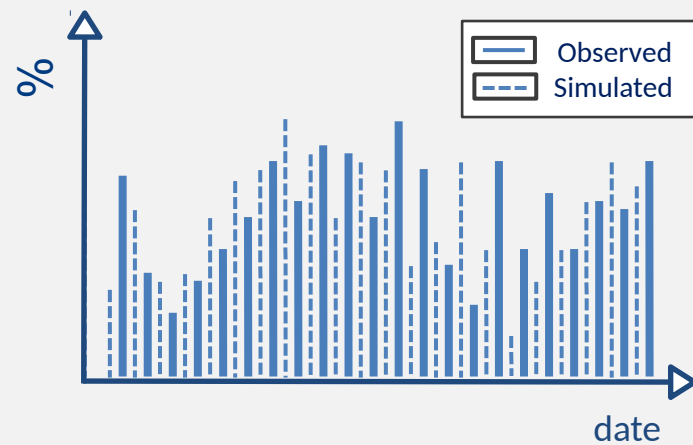
$$FO = \sum_{site*saizon} \sum_t (simulated(t) - observed(t))^2$$



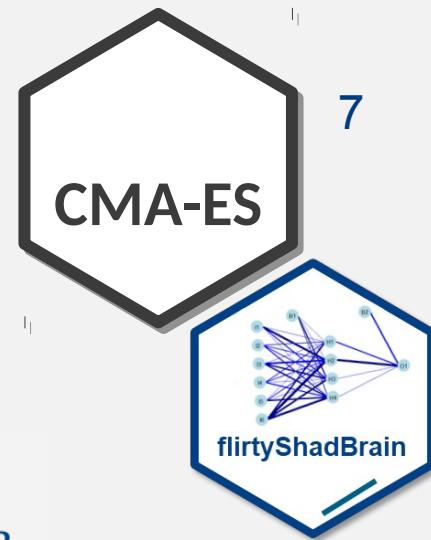
A minimiser



Sum of squared errors of prediction (SSE)



flirtyShadBrain: la construction de la fonction objectif



$$FO = \sum_{site*saizon} \sum_t (simulated(t) - observed(t))^2$$

$$+ \sum_{site*saizon} 1000 * (\sum_t(simulated(t)) - 1)^2$$

Ø Compensation des erreurs entre site x saison

flirtyShadBrain: la construction de la fonction objectif

CMA-ES

7

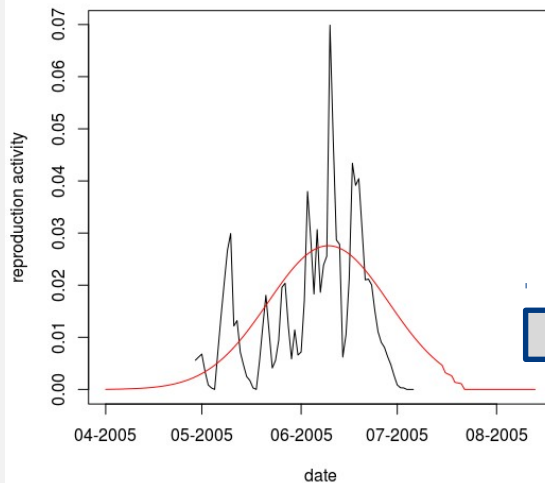
flirtyShadBrain

$$FO = \sum_{site*saizon} \sum_t (simulated(t) - observed(t))^2$$

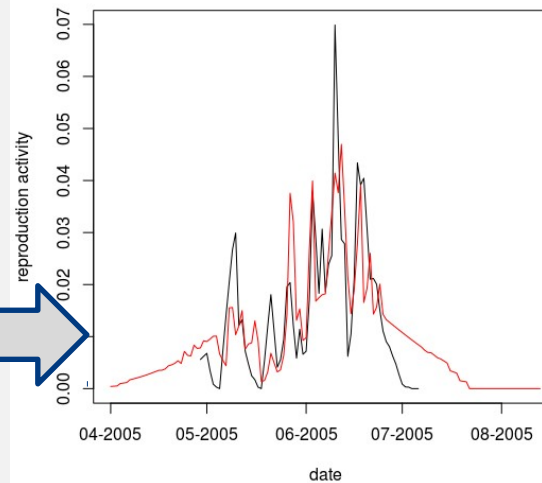
$$+ \sum_{site*saizon} 1000 * (\sum_t (simulated(t)) - 1)^2$$

$$+ \sum_{site*saizon} 1000 * [sd(proba(t) < 0.1)] * (sd(proba) - 0.1)^2$$

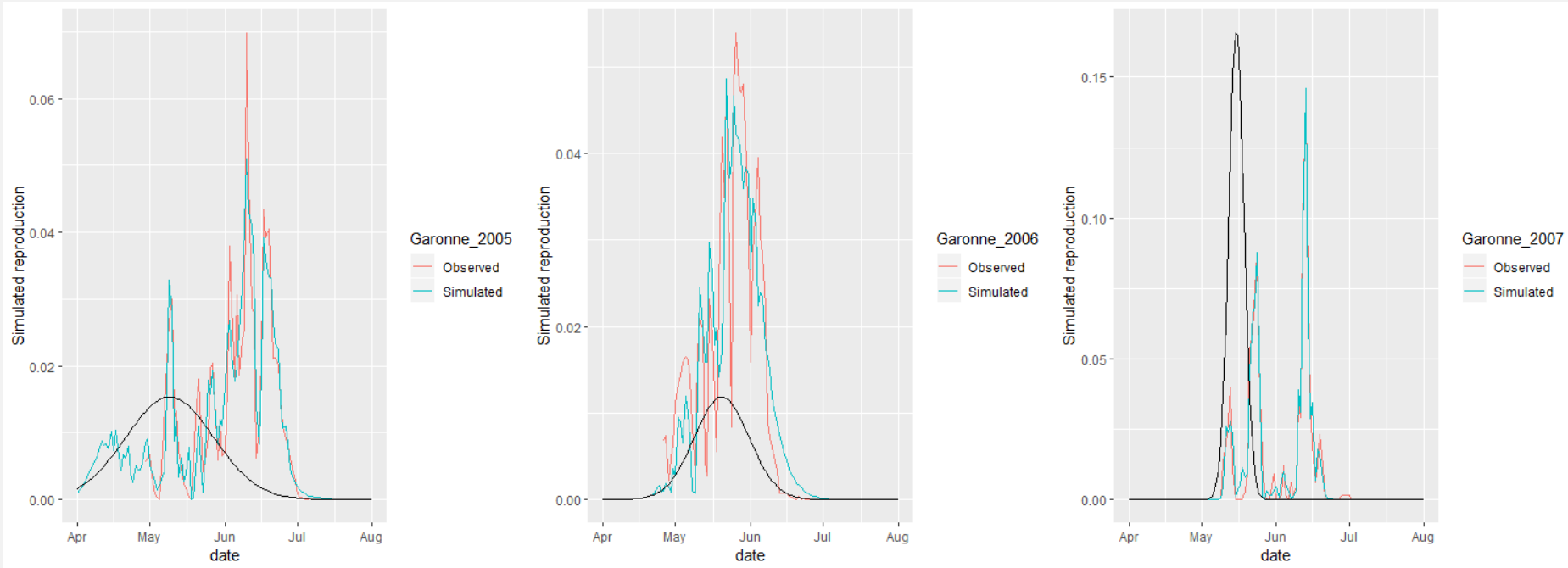
Garonne_2005 replication 0: SSE = 0.06166, r2 = 0.2168



Garonne_2005 replication 1: SSE = 0.02582, r2 = 0.6934



flirtyShadBrain: calibration du modèle!!



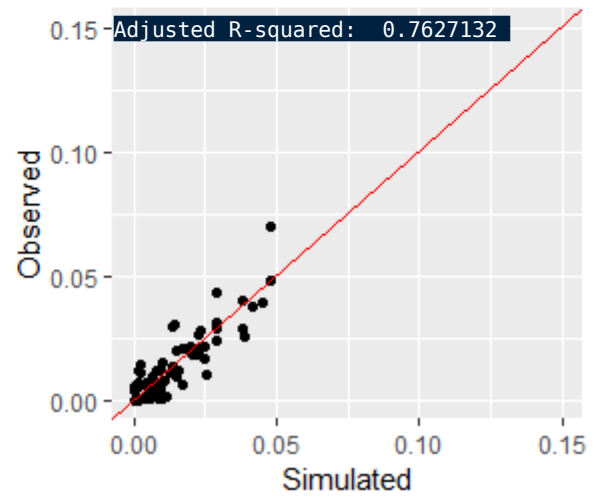
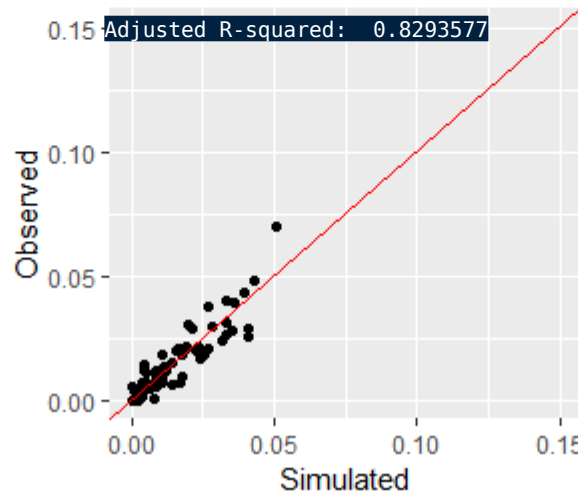
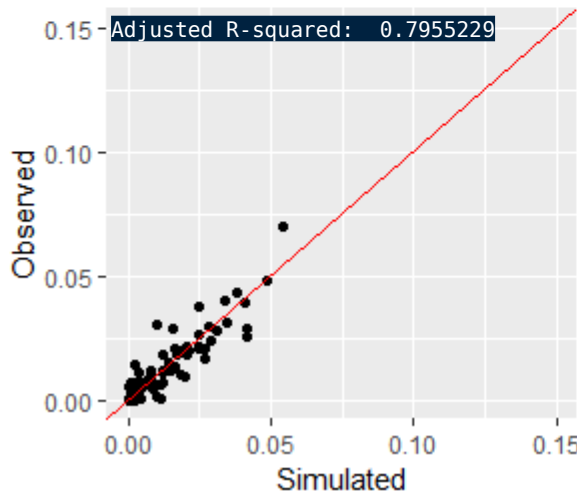
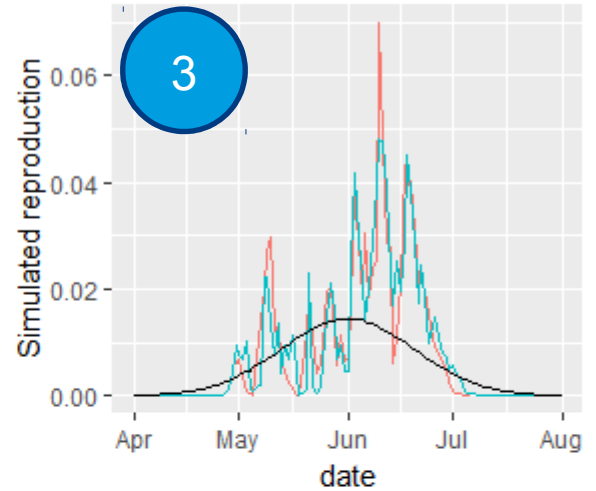
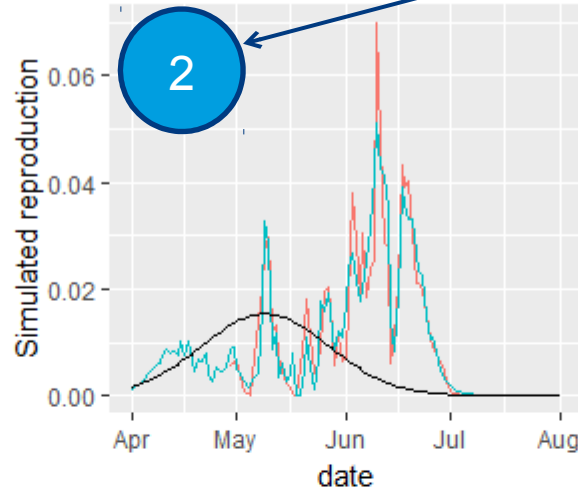
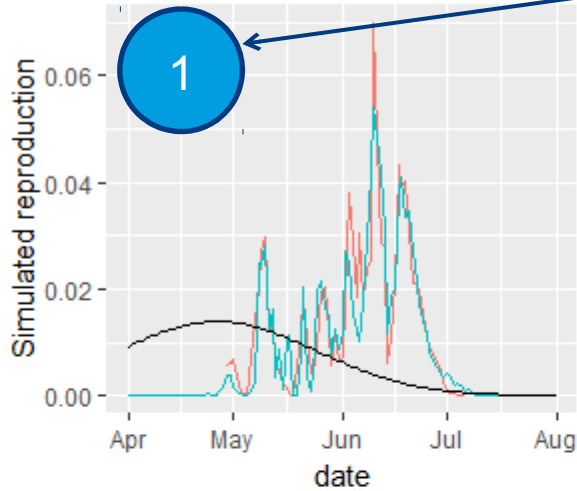
Temps de simulation par site année=0.05 seconde

Robustesse de la calibration par CMA-ES?

flirtyShadBrain: Robustesse de la calibration par CMA-ES?

Exemple de la Garonne en 2005

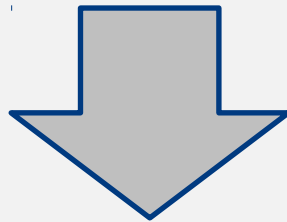
Graines de CMA-ES



flirtyShadBrain: Robustesse de la calibration par CMA-ES?

La méthode d'Olden

Importance de chaque variable
à partir du produit des poids
entre chaque neurone



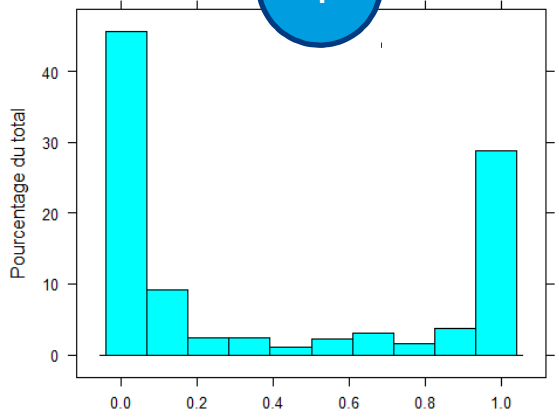
Appliquée pour les 3 années
en Garonne
et 3 graines différentes



The flirtyShadBrain: évaluation de 3 calibration du modèle

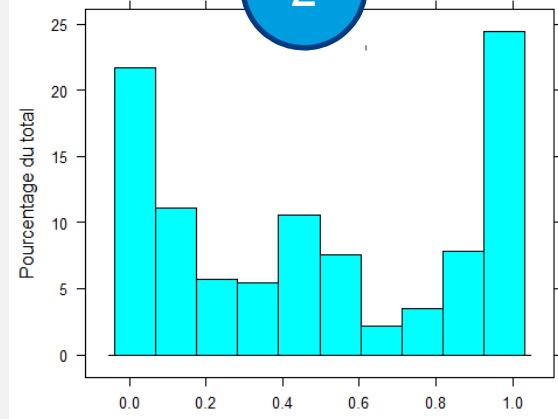
Graines de CMA-ES

1



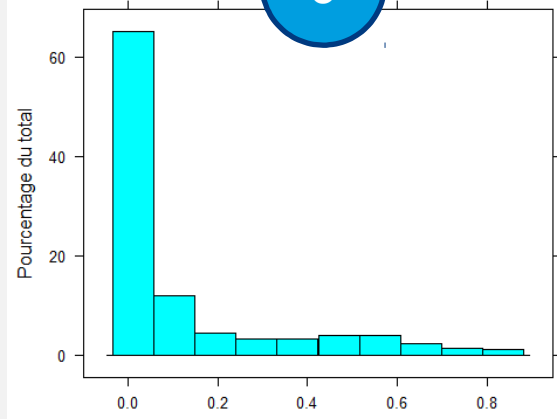
Probabilité du RN

2

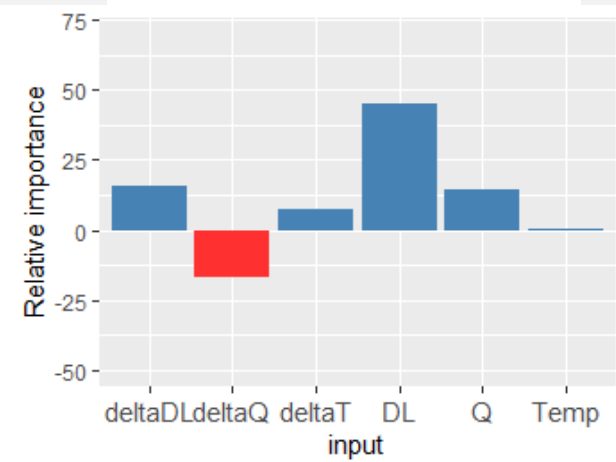
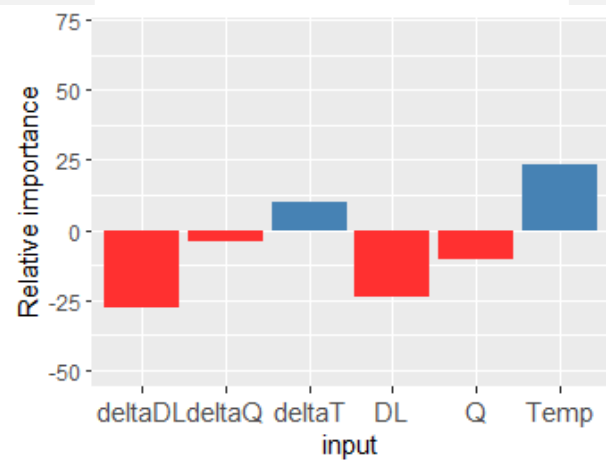
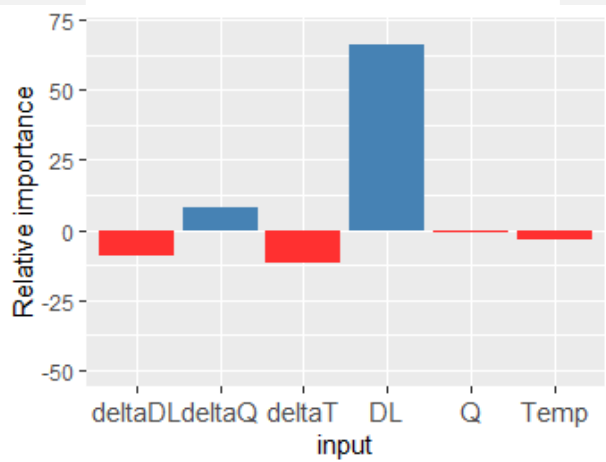


Probabilité du RN

3



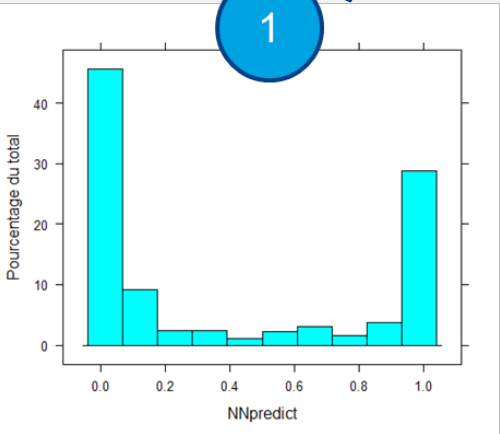
Probabilité du RN



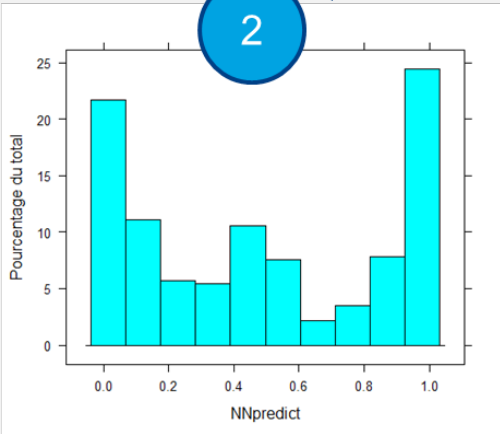
The flirtyShadBrain: évaluation de 3 calibration du modèle

Graines de CMA-ES

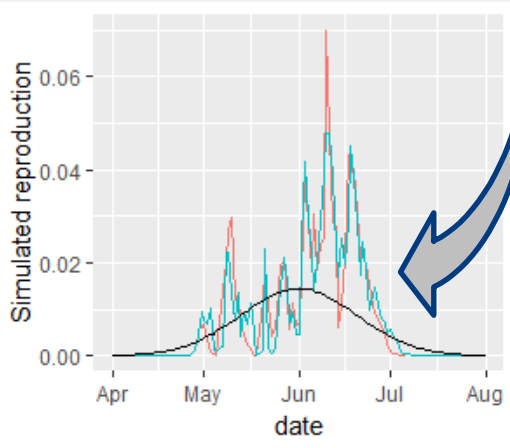
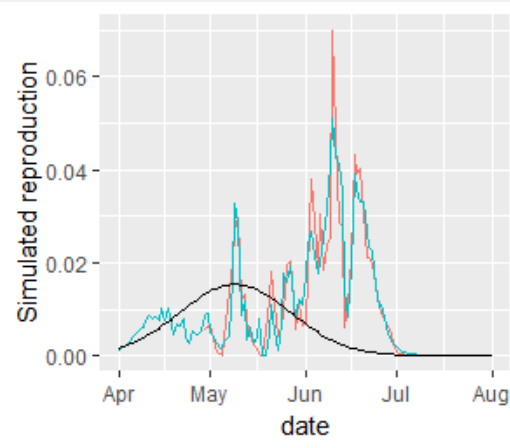
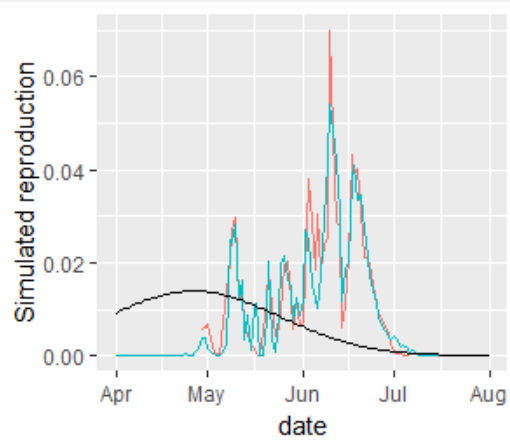
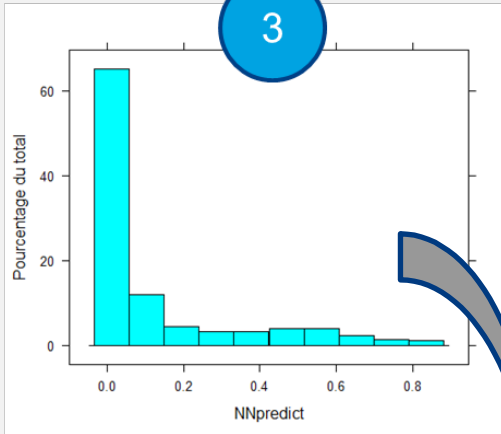
1



2



3



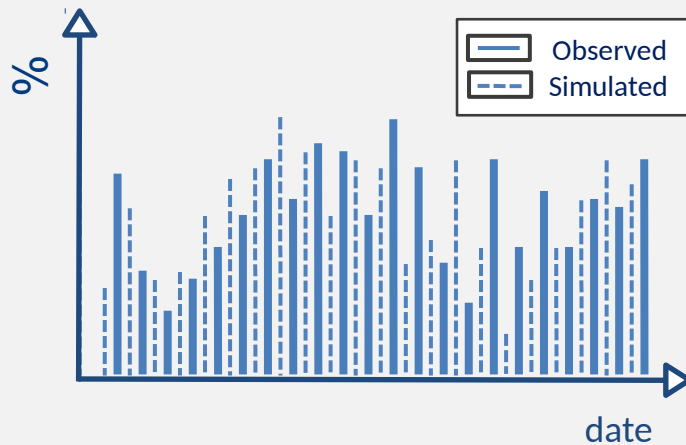
30 jours
3 reproductions
Espacées de 2 jours

The flirtyShadBrain: évaluation de 3 calibration du modèle

R^2



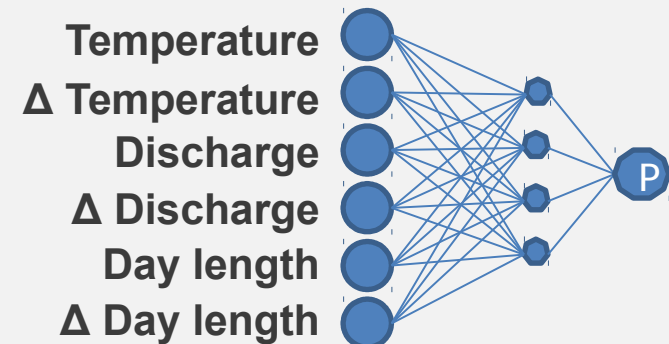
=



Olden's method



≠



flirtyShadBrain: un modèle de reproduction simulée

Le bilan



Plusieurs règles de décision difficile à caractériser,
mais qui aboutissent à une chronique de ponte relative similaire
→ biologiquement acceptable ou fonction objectif mal définie?

Les pistes de réflexion à explorer

1. Les conditions environnementales ne sont pas suffisamment discriminantes pour faire la différence entre différentes pondérations du réseau de neurones
2. Les contraintes biologiques agissent comme un lisseur \square minimise les différences de réponses entre les calibrations du réseau de neurones

flirtyShadBrain: un modèle de reproduction simulée

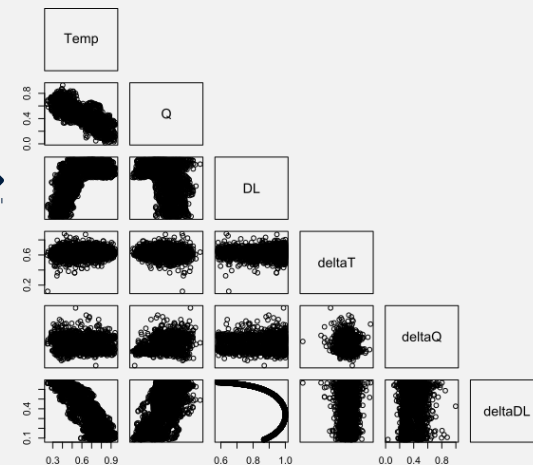
Le bilan



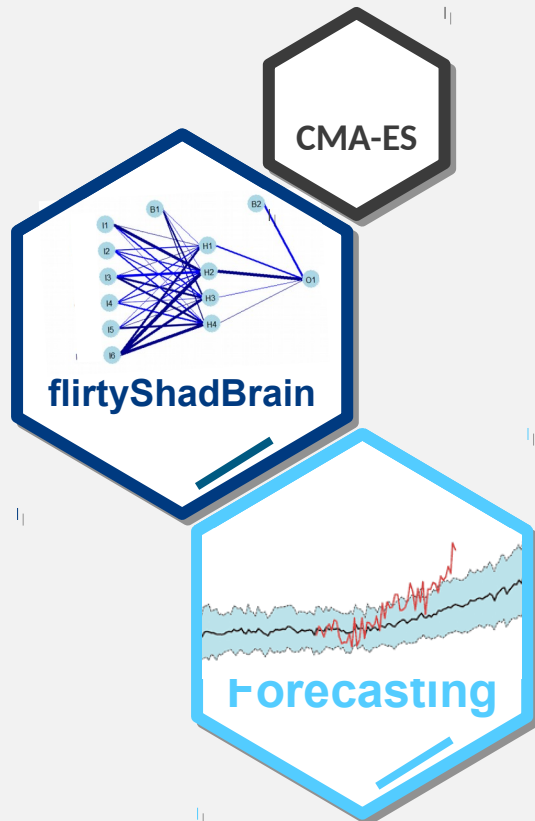
Plusieurs règles de décision difficile à caractériser, mais qui aboutissent à une chronique de ponte relative similaire
 → biologiquement acceptable ou fonction objectif mal définie?

Les pistes de réflexion à explorer

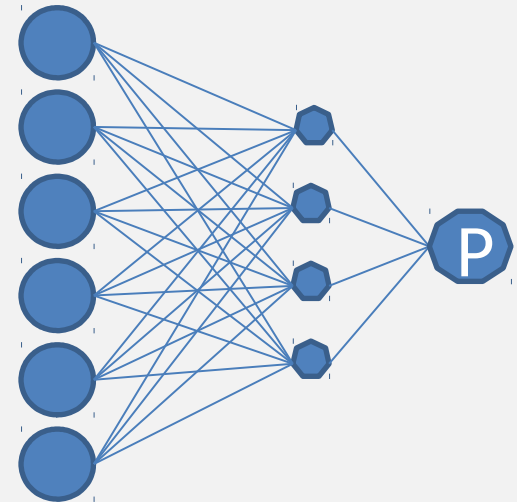
4. Le jeu d'apprentissage est trop petit... approche de validation croisée en cours (pouvoir prédictif)
5. Trop de minimums locaux ?
6. Modèle sur-paramétré, diminution des inputs →
7. Les réseaux de neurones, pas le meilleur outil ?
8. Biologiquement acceptable?



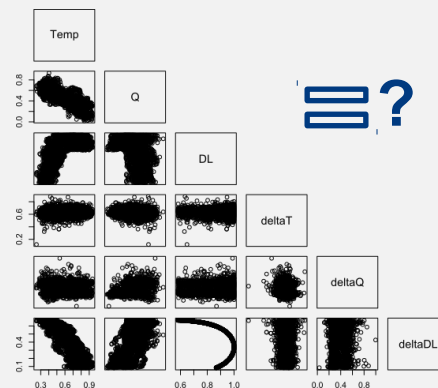
The flirtyShadBrain: impact du changement climatique

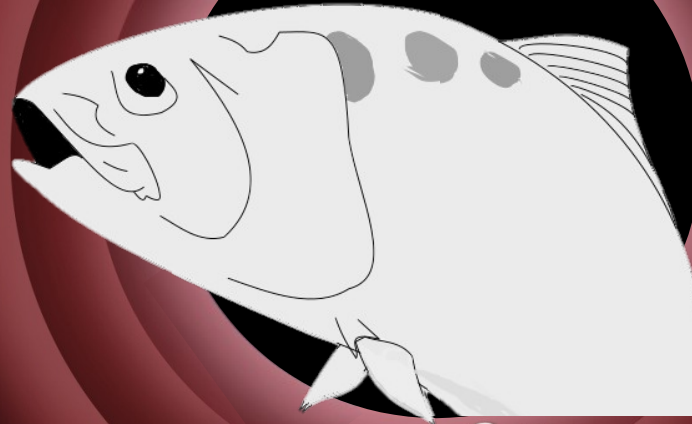


Temperature
 Δ Temperature
 Discharge
 Δ Discharge
 Day length
 Δ Day length



« Oublie que t'as aucune chance, vas-y force ! On sait jamais, sur un malentendu ça peut marcher ! »





That's all folks!



www.irstea.fr



AGENCE DE L'EAU
ADOUR-GARONNE



RÉGION
**Nouvelle-
Aquitaine**

Alexis Paumier
Doctorant à IRSTEA Bordeaux